Characterization of the Organic Carbon in the Tagish Lake Meteorite by C-XANES Spectroscopy

G.J. Flynn (SUNY-Plattsburgh), L.P. Keller (NASA Johnson Space Center), C. Jacobsen (SUNY, Stony Brook) and S. Wirick (SUNY, Stony Brook)

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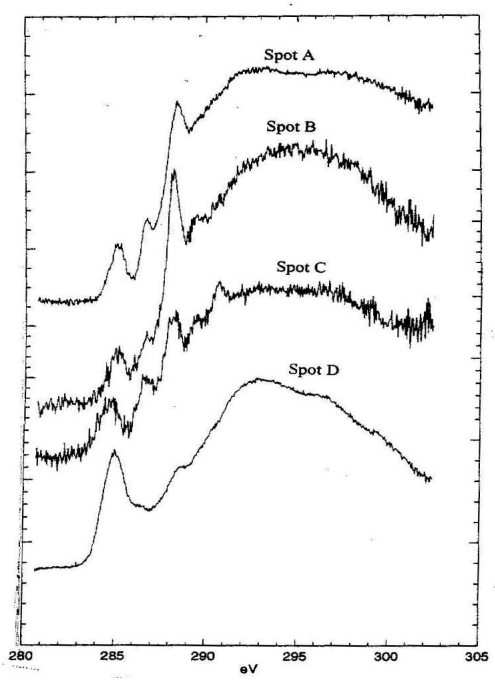
Introduction: The CI carbonaceous chondrite meteorites have a solar-like chemical abundance pattern, suggesting that these meteorites have not experienced chemical fractionation since the formation of the Solar System. The carbonaceous chondrite meteorites contain organic carbon, and the study of this organic matter helps to understand the origin of organic matter in our Solar System and provides clues to the types and abundances of pre-biotic organic matter available for the origin of life on Earth.

The Tagish Lake meteorite, which fell in British Columbia in January 2000, appears to be a new type of carbonaceous chondrite, classified as a CI2 meteorite (Brown et al., 2000). This distinguishes Tagish Lake from all other CI carbonaceous chondrites, which are classified as CI1 meteorites, in that Tagish Lake has experienced less aqueous alteration than the other CI chondrites. Thus the Tagish Lake meteorite may provide the opportunity to study organic matter that has experienced less severe aqueous alteration than that in the other CI carbonaceous chondrites. Preliminary characterization of small fragments of Tagish Lake indicate that it contains 5.4 wt% carbon, mostly present as carbonate (3.7 wt%) but also including a significant amount of organic carbon (Brown et al., 2000).



Methods and Materials: We first measured the trace element content of a chip from an ~30 mg fragment using the X-Ray microprobe at X26A, and found no evidence for elemental contamination of this Tagish Lake sample (Flynn *et al*., 2000). Another small chip from this ~30 mg fragment was embedded in elemental sulfur, ultamicrotome thin sections were cut, and these sections were deposited on an SiO substrate. We performed a preliminary survey of the carbon in a single 10 x 30 micrometer ultramicrotome slice of Tagish Lake. We imaged the section at energies above and below the C K-edge, and generated a map of the carbon distribution in the section. We then obtained X-ray Absorption Near Edge Structure (XANES) spectra over the energy range from 280 to 305 eV at carbon-rich spots on the section (see figure).

Results: The carbon map indicated that carbon was abundant in this section. Highly absorbing submicron carbon-rich grains and larger but less strongly absorbing regions of carbon-rich material were identified. We obtained four distinctly different XANES spectra. Spectra like Spot C and Spot D were obtained on the strongly absorbing grains, while the less strongly absorbing regions gave spectra like Spot A and Spot B. Spot A shows three pre-edge absorptions near 285 eV, 286.5 eV, and 288 eV. The Spot A spectrum is very similar to the C-XANES spectrum of organic matter extracted from the CM2 carbonaceous meteorite Murchison. The spectrum taken at Spot B is similar to that at Spot A except that the 288 eV absorption, resulting from carbon-oxygen bonding, is larger than in the Spot A spectrum. This suggests at least two types of organic carbon are present in this Tagish Lake sample. The Spot C spectrum shows an additional absorption just above 290 eV, consistent with carbonate (which was also identified by TEM and FTIR examination of Tagish Lake). The carbonate grains in this section were all small (<1/2 micrometer in size) and were spatially associated with organic material. The Spot D spectrum, dominated by the 285 eV absorption, is consistent with reference spectra of amorphous carbon.

Conclusions: The one small area of the Tagish Lake meteorite that we examined contains at least four distinct types of carbonaceous material: carbonate, amorphous carbon, and two spectrally distinct organic components. Further examination of Tagish Lake with the Scanning Transmission X-Ray Microscope is required to fully characterize the types and spatial distribution of carbon in this meteorite.

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References: P. G. Brown *et al*., The Fall, Recovery, Orbit, and Composition of the Tagish Lake Meteorite: A New Type of Carbonaceous Chondrite, Science, 290, 320-325, 2000. G. J. Flynn *et al*., Chemical Composition of a Unique Carbonaceous Chondrite Meteorite -- Tagish Lake, NSLS Annual Activity Report, 2000.